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Development of national space governance and policy trends in member states of the European Space Agency

Daniel Sagath[a], Christopher Vasko[b], Elco van Burg[a,*], Christina Giannopapa[b]

[a] Vrije Universiteit Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, the Netherlands
[b] European Space Agency, 8-10 Rue Mario Nikis, 75738, Paris Cedex 15, France

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ABSTRACT

The European Space Agency (ESA) has been the main programmatic and industrial capacities development organisation of the European space sector since its establishment in the early 1970s. Understanding the national policies of its member states is crucial for the future development of a coherent European space policy. Over the last years, ESA has developed a methodology to track the development of national space policies of its member states and collaborating states. The "Member States Observatory" is a basic resource for understanding the complexity of the European national space strategies available to the national delegates, ESA experts and employees. The main objective of this study is to present the findings and methodology of two surveys performed in 2013 and 2017, in order to identify the main space strategy developments of the ESA member states. The study suggests two main dimensions, which serve to identify trends in ESA member states. These are space *governance structure* and *public policy priorities* in technology domains, areas of sustainability, and motivations for engaging in space activities.

1. Introduction

Factors that drive national space policies and shape national space governance in Europe are an important, yet relatively complex, topic for research. These factors are constituted by the complexity of actors, organisations, and programmes that shape the European space sector. Furthermore, the number of European states composing their space strategy and policy is on the rise, which in turn triggers national policy makers to revise existing strategies in line with current developments of the European space sector landscape.

Space policy is a particularly interesting and dynamic field of research, as it includes many horizontal (across different public policies) and vertical (from states to respective international governmental organisations - IGOs) dimensions to consider. For example, since its establishment, the European Space Agency (ESA) brings state actors together under a specific setting as an intergovernmental organisation. It steers (a peaceful) scientific and industrial cooperation amongst its member states including responsibility in developing a coherent European space policy [1]. Second, European states themselves formulate and shape their national space strategies including reflection to other state interests. Thirdly, the European Union (EU) as a supra-national organisation [2] builds its own space strategy and programmes, including collaboration amongst European countries and other organisations such as ESA. Together, these actors influence national space strategies and programmes.

There have been a few systematic efforts to facilitate the understanding of exchange and coordination of national space strategies and programmes (e.g., [3,4]), including studies on European space policy

Abbreviations: ALR, Austrian Aeronautics and Space Agency; BELSPO, Belgian Space Policy Office; BEUR, Billion Euro; CAP, Calls for Outline Proposals; SAITSD, Czech Space Activities and Intelligent Transport System Department; EI, Enterprise Ireland; ECS, European Cooperating State; EDA, European Defence Agency; GSA, European Global Navigation Satellite Systems Agency; EUMETSAT, European Organisation for Exploitation of Meteorological Satellites; ESA, European Space Agency; EU, European Union; EUSC, European Union Satellite Centre; TEKES, Finnish Funding Agency for Technology and Innovation; CNES, French National Centre for Space Studies; DLR, German Aerospace Centre; GDP, Gross Domestic product; HSO, Hungarian Space Office; IIS, Industrial Incentive Scheme; IGO, International Governmental Organisations; ITU, International Telecommunications Union; ASI, Italian Space Agency; MEUR, Million Euro; NSO, Netherlands Space Office; PECS, Plan for European Cooperating State; POLSA, Polish Space Agency; R&D, Research and Development; ROSA, Romanian Space Agency; S&T, Science and Technology; STI, Science: Technology and Innovation; SSO, Swiss Space Office; UKSA, United Kingdom Space Agency; UNCOPUOS, United Nations Committee on the Peaceful Uses of Outer Space; VU, Vrije Universiteit Amsterdam

* Corresponding author. Vrije Universiteit Amsterdam, School of Business and Economics, De Boelelaan 1105, 1081 HV, Amsterdam, the Netherlands.
E-mail addresses: d.sagath@vu.nl (D. Sagath), christopher.vasko@esa.int (C. Vasko), j.c.van.burg@vu.nl (E. van Burg), christina.giannopapa@esa.int (C. Giannopapa).

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development (e.g., [5,6]). In recent years ESA has contributed to this understanding by developing a methodology to track the national space policies of its member states and collaborating states, which, partly in collaboration with Vrije Universiteit Amsterdam (VU Amsterdam) resulted in a number of practitioner publications [7–10]. These publications include two executive studies, referred to as the 'Countries Overview: Info Notes on Member States', which present a guideline for understanding the complexity of the ESA member states' national space strategies, policies or governance. These studies were published in 2014 and 2017 in form of ESA internal reports. Their main purpose was to create a comprehensive information collection considering space policy and governance trends and make it available to the member states' delegates, ESA experts and employees.

Using the surveys and results of these two executive studies, the main objective of this paper is to contribute to the current debate on European space policy. This study explores how the national-level policies and administration are shaped and what dimensions define the evolution of the European space policy. We identify two key dimensions that shape European space policy. First, the space *governance structure* is important, which refers to the public administration structure and responsibilities of national government bodies related to space matters. Second, *public policy priorities* for space refers to the importance of a member state's technology domains, their areas of sustainability, and motivations for engaging in space activities.

This paper is structured into four sections. The first section presents the research setting, ESA's purpose, and the mechanisms and integration processes which drive the space sector's development. Second, this paper introduces the research design, data collection, and analysis. The third section of this paper shows the results of the surveys, including aggregated dimensions according to space governance and public policy priorities for engaging in space. The last section discusses the recent developments between the two periods of analysis.

2. Research setting

The understanding of complex relations, mechanisms and objectives of the European space sector is important for the development of European space policy. Since the creation of ESA, the number of its member states has more than doubled. ESA was created in 1975 by ten founding Members States and currently there are twenty-two member states, and this number might even increase in the future. This constant increase of the number of ESA member states clearly demonstrates ESA's leading role for the European space sector development, but also is a source of policy-making dynamics, affecting national space policies.

One of the most defining legal provisions that directly affects European space sector development is Article II of the ESA convention. This article describes the purpose of the Agency and gives it policy formulating power. ESA's policy formulating power can be achieved "by elaborating and implementing a long-term European space policy, by recommending space objectives to the member states, and by concerting the policies of the member states with respect to other national and international organisations and institutions, by elaborating and implementing activities and programmes in the space field, by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites; by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the member states" ([1], p. 13–14).

Currently, ESA is expanding its membership to countries which have joined the European Union since 2004. The Czech Republic, Romania, Poland, Estonia and Hungary have become full members of ESA between 2008 and 2015. Others, like Bulgaria, Latvia, Lithuania, Slovakia are soon to start their negotiations to become full ESA members. A current overview of the ESA integration process can be found in Table 1 (e.g., [8]). To summarise, the ESA integration process includes a set of actions on a bilateral basis (see Table 2) (adapted from [8]). Typically, the first step is the signature of an Agreement with the European Space Agency concerning the Space Cooperation for Peaceful Purposes. Following an official government request and a positive national industrial and capability assessment by ESA, the subsequent step is the signature and implementation of a European Cooperating State Agreement (ECS). This agreement includes a detailed Programmatic Chart of the Plan for European Cooperating States (PECS).

A prospective member state joining ESA enters a transition period lasting between five to nine years with the aim to meet certain objectives listed in Table 3 [8,11]. Member states that have joined ESA for a period of less than ten years are considered new member states. ESA has several tools how to develop member states' space sectors. For example, ESA is guaranteeing the return of investments made by its member states' in the form of annual budget contributions. The balance constituted by the application of industrial return principle, also known as the geographical return principle, the ability to choose which optional (selective) programme(s) a country will contribute to, and by following a coherent industrial policy recommended by ESA, plays a crucial role in developing and creating current new space sector capabilities in individual ESA member states.

To provide an overview, a classification of all ESA member states is established according to their ESA budget contributions and their Gross Domestic Product (GDP). Fig. 1 plots the 2018 budgets of ESA member states against their respective GDP. It identifies small members states (with ESA annual contribution below 60 million EUR), medium-sized member states (with ESA annual contribution up to 200 million EUR), and large member states (with contribution above 200 million EUR). The categorisation is based on contribution to ESA in absolute numbers, not relative to the member states' GDP (e.g., [7]).

3. Methodology

After collecting archival data in the form of national space strategies, plans, or roadmaps published in two periods of 2013 and 2017, and creating a concise overview of each member state, a content analysis was performed (e.g., [12,13]). The common public policy priorities and governance dimensions found across the multiple national strategies were aggregated and organised according to the differences in public governance administration and respective horizontal policy-aspects such as technology domains, motivators for space, and areas of sustainability associated with each member state. The examples of ESA member states' strategies considered for the data collection are presented in Table 4. Something is considered as national space strategy if it is either published and communicated in a dedicated strategic document or if it is part of a larger national science-, technology-, or innovation policy, or research and development policy. Larger member states have dedicated strategies, whereas some small and medium-sized member states have opted to include space as a part of their broader innovation strategy. Some member states have not explicitly publicly published (or updated) their space strategic and policy objectives.

After analysing these documents, ESA member states' delegations were consulted with the results and asked to provide additional information during workshops that took place in October 2013 and September 2017 within ESA on the exchange of national strategies and plans.

4. Research results

4.1. ESA member states space governance

The space governance structure determines in particular who has decisions-making powers, and to what extent, and defines which national entity acts as the nation's representation to ESA. It allows to visualise how the integration of various stakeholder interests is

Table 1
Cooperation and integration process to ESA including integration to EU (adapted from [8]).

Country	EU Association or Free trade Agreements	EU Accession	ESA Coop. Agreement	ESA ECS Agreement	ESA PECS	ESA Convention	Industry Incentive Scheme
Austria	–	1995	–	–	–	1986	–
Belgium	–	1957	–	–	–	1978	–
Bulgaria	1995	2007	–	2015	2016–21	–	–
Croatia	2005	2013	2018	–	–	–	–
Czech Rep.	1995	2004	1996	2003	2004–8	2008	2009–2015
Cyprus	1973	2004	2009	2016	–	–	–
Denmark	–	1973	–	–	–	1977	–
Estonia	1998	2004	2007	2009	2010–14	2015	2016–2021
Finland	–	1995	–	–	–	1995	–
France	–	1957	–	–	–	1980	–
Germany	–	1957	–	–	–	1977	–
Greece	1961	1981	–	–	–	2005	–
Hungary	1994	2004	1991	2003	2004–13	2015	2016–2021
Ireland	–	1973	–	–	–	1980	–
Italy	–	1957	–	–	–	1978	–
Israel	2000	–	2011	–	–	–	–
Latvia	1998	2004	2009	2013	2013–17	–	–
Lithuania	1998	2004	2010	2014	–	–	–
Luxemburg	–	1957	–	–	–	2005	–
Malta	1971	2004	2012	–	–	–	–
Netherlands	–	1957	–	–	–	1979	–
Norway	1994	–	–	–	–	1986	–
Poland	1994	2004	1994 and 2002	2007	2008–12	2012	2012–2019
Portugal	–	1986	–	–	–	2000	–
Romania	1995	2007	1992	2007	2007–2011	2011	2011–2019
Slovakia	1995	2004	2010	2015	2016–2020	–	–
Slovenia	1999	2004	2008	2010	2010–2015	2016[a]	–
Spain	–	1986	–	–	–	1979	–
Sweden	–	1995	–	–	–	1976	–
Switzerland	1973	–	–	–	–	1976	–
United Kingdom	1955	1973	–	–	–	1978	–
Turkey	1964	–	2004	–	–	–	–
Ukraine	1998 (2017)	–	2008	–	–	–	–

[a] Slovenia is associate member to ESA.

facilitated. Each ESA member state has a unique governance structure when it comes to space (e.g., [9,10]). Moreover, each member state participates in a number of organisations engaged in space activities or is responsible for other international arrangements. These organisations in Europe include ESA, the European Organisation for Exploitation of Meteorological Satellites (EUMETSAT), the European Union Satellite Centre (Satcen), the European Global Navigation Satellite Systems Agency (GSA), the European Defence Agency (EDA), the International Telecommunications Union (ITU), and the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).

Different ministries focus their attention on different aspects of space policy, seeking to support their positions. This may result in various governance models, which depend for example on the responsible ministries for space. The analysis shows that the typical ministries involved in overseeing cooperation via international organisations are in general related to science, technology, research and education; economy; industry, innovation; transport, communications, defence, environment, energy, and foreign affairs. In some cases, the prime ministers' office is responsible for space policy implementation.

Fig. 2 shows the ministries responsible for space in ESA member states [14]. Regarding the ministry responsible for ESA, education or science ministries are traditionally in charge. Other states opt to cover space under the ministry of economy or industry and innovation. Recognising the transverse nature of space and its potential role for number of sectorial policies, transport or environment can also be encharged with the space resort. Furthermore, ESA space governance is frequently shared and/or delegated to multiple ministries, for instance transport and (tele-)communications, environment, energy or defence. In practice, a single ministry has the leading responsibility for ESA space activities with one or multiple other ministries with secondary space responsibilities.

Fig. 3 shows an archetypical model of space governance, including ministries and other governmental agencies overseeing collaboration with international organisations. As an example, the national institute for meteorology is frequently located under the umbrella of the ministry of environment, and is often responsible for the delegation to EUMETSAT. Delegations to EDA and EUSC (Satcen) are typically under the responsibility of the ministry of defence, while the ministries of foreign affairs are in many cases charged with representation at UNCOPUOS. Aspects related to satellite communications often resort under the competence of the ministry of transport and/or communications. This is reflecting the implementation of policy and regulations by telecommunications agencies and representation to the ITU.

Finally, ministerial delegations to the EU dealing with Galileo and GSA are typically linked with the national ministries for transport and telecommunications, regardless of which ministry is responsible for ESA. In addition to the roles of specific ministries, the role of the ministries of foreign affairs and the prime minister's offices in coordinating space activities at national and international/supranational level should not be underestimated. The ministries of foreign affairs are directly involved in the representation of their respective countries in international organisations and complement specific ministries, for instance through the permanent representation to the EU.

Each member state's particular governance structure is based on the own national environment and specificities. Regardless of the type of the governance structure chosen by a member state, the following points must be achieved: a coordinated approach towards the various fields of space activities, no duplication of efforts, setting out a national space policy/strategy and overseeing its progress, coordinating representation in space related bodies, and coordinating a coherent space budget. Implementing entities further manage the space activities across multiple ministries at the national and or regional level.

Table 2
ESA mechanisms for integrating new member states.

ESA integration mechanisms	Description of mechanism
1) Framework Agreement	- Formal agreement between ESA and a state on intention to become an ESA member state. - Only allows the exchange of experts from both signature parties. - No budgetary or programmatic contributions. - After five years a decision to sign an ECS agreement may be made by the state.
2) European Cooperating State Agreement (ECS)	- This integration step intends to prepare the countries' space actors for a future successful accession to the ESA convention. It focuses on developing concrete collaboration activities at project level and strengthening the national expertise and capabilities in non-member state countries. - Provision of political and programmatic guidelines for investments in the national space sector, support for further development of the national space policy. - Typically for five years with possible extension. - Primary aim is to achieve a detailed understanding of the national scientific interest and capability together with the industrial base of the European space sector. - Contains measures to secure and increase non-member state industry participation during the ECS period in the supply chain networks of the ESA member states. - ECS countries have the possibility to participate in ESA activities and programmes and become familiar with the ESA rules and procedures.
3) Plan for the European Cooperating State (PECS)	- Purpose is to provide the possibility directly participation of non-member states' space industry in ESA projects. - Identification of potential capabilities and guiding it towards the ESA procedures and standards of industrial and scientific collaboration. - After the ratification of the ECS agreement, ESA conducts an industrial assessment in each ECS country. - PECS calls for proposals aimed at attracting potential industry and institutes to engage in ESA projects. - The ESA PECS office with the ESA external relations office are the agency's liaisons with the ECS country. It is engaged in the selection committee that decides on the projects that would be awarded after the PECS calls. - The PECS committee meets twice a year to discuss and approve the new PECS projects in accordance with decisions of particular ESA programme boards and committees responsible for on-going projects under which the collaboration is foreseen. - The final decision on approved PECS programme collaboration is made by the ESA industrial policy committee together with delegation in order to align PECS projects with the existing ESA projects. - Once the *PECS Programmatic Chart* is approved, including the results of the successful PECS calls on project proposals, all ESA Directorates are invited to present their activities and provide updates about the ESA programmes. - The budget to be allocated by an ECS for collaboration within the PECS is at a minimum of €1 million per year (at 2001 economic conditions) for a minimum period of 5 years. - The calls for PECS proposals are repeatedly open until the whole 5-year contribution is redistributed back to the national industry. After the 5-year period of PECS the ECS state can initiate the accession to ESA convention.
4) Associate Member State	- Provision of the possibility to flexibly engage in ESA activities and programmes. - According to the ESA convention (Article XIV), the decision on Associate membership requires two-third majority of the ESA council. - This type of associated membership in ESA allows to carry out opportunities for participation in optional programmes without the obligation of the mandatory contributions. - The choice of participation is based on national interests, science and technology (S&T) and industrial capabilities. - The national delegates are represented at the ESA committees and programme boards.
5) Accession Agreement to the ESA Convention	- Triggered by the respective government's request to the Director General of ESA. - ESA council must approve upon proposal by the Director General. - The Accession Agreement contains a number of major provisions including: the amount of the entry fee, established by ESA council; the Transitional Arrangements, in particular the provisions for an Industrial Incentive Scheme (IIS); the reciprocal duties and obligations during the Transitional Period; and the fact that at the end of the Transitional Period, the geographic return statistics of the mandatory programmes and activities for the given new member state will be discontinued. - This assessment focuses on technology and industrial capacities (past and on-going), including the size and extension of the industrial landscape involved or interested in space activities.
6) Industrial Incentive Scheme (IIS) and Transition Period	- Associated with each new member state and aims to create, support and foster industrial capacities, in order to achieve stable industrial return for the member state after the transition period. - Within the IIS, the activities recommended for implementation follow ESA standard procurement rules and procedures. The transition period is at least five years and the budget allocated to the IIS is usually fixed to 45% of the mandatory contribution of the new member state (mandatory contribution is calculated according the GDP of member states). - An IIS Task Force is comprised of representatives from ESA and the new member state is tasked with advising on specific measures to be implemented under the IIS. - The contracts are awarded though Calls for Outline Proposals (CAP). Accepted proposals must have a solid technical/scientific content, fall within the outlined programmatic objectives and should be within the budget allocation of the given CAP.

The current dynamics in the European space sector reflect the tension and consensus between its actors: the ministries responsible for space and the national space policy implementing entities. As the importance of the space sector for industry grows, a shift of responsibilities to the ministry dealing with industrial competitiveness and innovation is observed. However, engagement in ESA can be mainly found under three ministries: science and education (e.g., France, Italy, Denmark, Sweden, Greece, Portugal, or Romania), industry and innovation (e.g., the United Kingdom, Ireland or Norway), and economy (e.g., Germany, The Netherlands, Finland, Switzerland, Spain, Luxembourg, Estonia or Poland). It is not uncommon that space competences are moved from one ministry to another, since the perception of where space can best serve is changing as the sector is becoming more mature and acts as multiplier in other policy areas. The most recent trend is to place space within the ministry of economy, highlighting the importance of space as a multiplier of public funding and its transverse nature to a number of policies.

The research analysis identified three distinct types of space policy administration. Usually referred to as (1) space agency, (2) space office, or (3) a ministerial department unit dealing with multiple other public policy issues (for a summary see Table 4). The space agency is typically an entity which combines the development of policy and strategy, the

Table 3
ESA Guidelines towards a sustainable membership (sources: [8,11]).

Domain	Objective
Industrial return including mandatory activities	For the overall industrial return, a tangible value has to be reached for each new member state, including for science and other mandatory programmes.
National Space Strategy	The early definition of a national space strategy provides a tool that prioritises proposals for ESA programmes (mandatory and optional), as well as in national space activities. It introduces transparency regarding national objectives providing a frame for institutional and private investment.
Formal support structure	There is an essential need of a formal structure acting in support of the delegation for a smooth participation in ESA. A formal structure, or even a national programme, with resources proportional to respective ESA supports the liaison with industry.
Subscription to optional programmes	Definition of priorities and of optional programmes to which each state decides to participate in, is an essential element in order to create and foster capacities with the purpose of gradually achieving a balanced participation of industry to selected ESA programmes, and not only to mandatory activities.
Space Industrial Association	A national space industrial association coalesces disparate national industrial interests and provides an interlocutor to the national delegation to identify priorities and guidelines. It also serves as advisor and can be used as an important player in the tasks of industrial liaison.
Academia and industry	In a new member state with little experience in space activities, academia tends to play a disproportionate role due to mature research and scientific capabilities. However, for sustainable participation in ESA, the participation of industry is essential.
Space hardware	The achievement of this objective is usually easy to quantify: it reflects whether the national industry and academia were able to acquire the capabilities, facilities and know-how during the transition period to develop space hardware pertinent to all ESA programmes.
Supply chain	The achievement of this objective reflects whether national industry has managed to establish a stable relationship with other European space industries, on a complementarity basis.

management of procurement contracts and in-house research and development contracts. The power of such agencies differs, ranging from establishing a national space strategy, to awarding national contracts, conducting research and development, making binding commitments vis-à-vis ESA, to representation roles to other organisations. National space agencies generally handle all national, European and international space activities including for example co-representation of the country in the United Nations (UNCOPUOS). This type of space administration is typical for well-established countries in the sector, with significant budget contributions to space and with rather independent space policies complementary to ESA activities.

A space agency is typically reserved for larger ESA member states who have the resources to conduct and manage both national and international space research. Examples of agencies of member states are the French National Centre for Space Studies (CNES), the German Aerospace Centre (DLR), the Italian Space Agency (ASI) and the UK Space Agency (UKSA). Typically, the ESA member states with substantial budgets tend to have space agencies in order to organise their research agendas via different organisations and in multiple thematic areas. However, also small ESA member states are found to have-full scale agencies, such as the Romanian Space Agency (ROSA), Austrian Aeronautics and Space Agency (ALR) and the Polish Space Agency (POLSA).

The second type of implementing entity is the space office. An office fundamentally differs from a space agency, mainly by being limited in scope to the role of the policy- and strategy-maker, by managing the

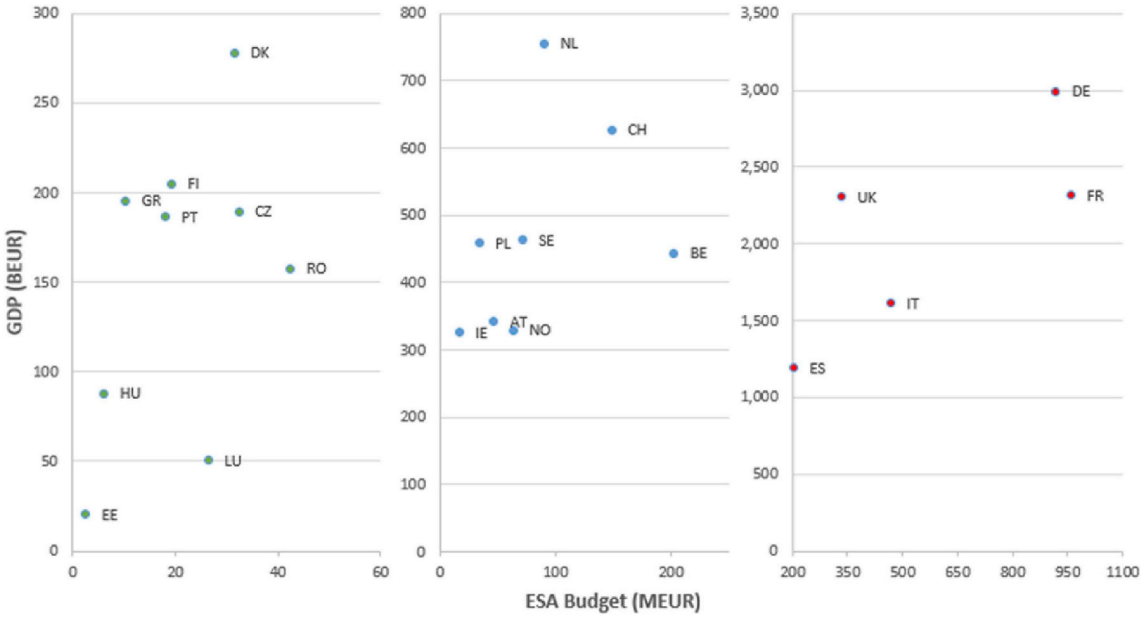

Fig. 1. ESA Member States 2018 ESA budget (MEUR) and 2018 GDP (BEUR). Acronyms: AT - Austria; BE - Belgium; CH – Switzerland; CZ – Czech Republic; DE - Germany; DK – Denmark; EE - Estonia; ES – Spain; FI – Finland; FR – France; GR – Greece; HU – Hungary; IE – Ireland; IT – Italy; LU – Luxembourg; NL – The Netherlands; NO – Norway; PL – Poland; PT – Portugal; RO – Romania; SE – Sweden; UK – United Kingdom [Sources: ESA and IMF World Economic Outlook].

space budget either internally or through ESA, and sometimes with procurement responsibilities for outsourced R&D contracts (e.g., technology incentive programmes). The mandate of such offices is consequently less elaborate compared to space agencies, although similar to space agencies their power is determined and governed by the specific national context. The space office is typically established within small and medium-sized ESA member states. This category includes for instance the Swiss Space Office (SSO), the Netherlands Space Office (NSO), the Belgian Space Policy Office (BELSPO), and the Hungarian Space Office (HSO).

The third option for space policy administration is a so-called (department) unit within a body with larger competence. The government bodies charged with space affairs are in these cases also responsible for a variety of other – related – areas, such as for instance science, technology, and innovation. Space is either fully integrated with other areas in the competence of the governmental body, or space receives a specific office or division within that governmental body (such science, technology and innovation (STI) agencies or industry and innovation agencies) or ministry. This structure typically exists – but not exclusively – in countries that are relative newcomers in space and/or smaller ESA member states. This structure typically exists in countries that are relative newcomers in space and/or smaller ESA member states. This category includes for instance Enterprise Ireland (EI), the Finnish Funding Agency for Technology and Innovation (TEKES), and the Czech Space Activities and Intelligent Transport System Department (SAITSD).

4.2. ESA member states public priorities

Most member states have broad interests in the entire scale of *technology domains* related to space activities (see Fig. 4) [14]. The relative importance of each technology domain differs from member state to member state. These technology domains represent activities such as earth observation, science, telecommunications, integrated applications, transportation, navigation, and human and robotic exploration (e.g., [9,10]). Furthermore, science and exploration are highly regarded by all member states, which may partially be induced by the foundation of ESA and by the inclusion of science in ESA's mandatory programmes (e.g., science or ESA basic activities). All other technology domains such as navigation, satellite communications or human and robotic exploration are well represented, partially due to historical reasons and industrial interests.

Through the analysis it was found that all member states engage in technology domains such as science and exploration, earth observation, and integrated applications. As an evident difference across the countries is that small member states are less likely to engage in human and robotic exploration and navigation. The analysis of the periods 2013 and 2017 shows that the development in technology domains in space is rather stable, with increasing interest in telecommunications and navigation. Further, it can be observed that all member states see potential in the development of their respective downstream (application) space sectors, evident by the considered integrated applications by all member states.

Space can serve as an important 'multiplier' to the six areas of sustainability due to its transversal nature (e.g., [9,10,15]): security, environment, energy, resources, knowledge and transport. Member states see multiple functions for space as an enabler for these areas (see Fig. 5) [14]. These are mostly a logical consequence of the concerned member states' historical, geopolitical, economical, geographical, financial and political position and outlook. For ESA member states with

Table 4
Space implementing entities and strategies in ESA member states.

Member state	Agency	Office	Unit	Implementing entity	National space (or innovation) strategy/policy
Austria	✓			Austrian Aeronautics and Space Agency (ALR)	Austria in Space – Strategy of the bmvit for Austrian Space Activities[a]
Belgium		✓		Belgian Space Policy Office (BELSPO)	
Czech Rep.			✓	Space Technology and Satellite Systems Dpt. (SSTSSD)	National Space Plan 2014–2019[b]
Denmark			✓	Space Division under Danish Agency for Science and Higher Education (DASHE)	Denmark's National Space Strategy[c]
Estonia			✓	Space Office (ESO) under Enterprise Estonia (EE)	Estonian space sector strategy 2011–2013[d] Estonian Space Action Plan 2016–2020[e]
Finland			✓	Finnish Funding Agency for Technology and Innovation (TEKES)	Finnish National Space Strategy 2013–2020[f]
France	✓			French National Centre for Space Studies (CNES)	Ambition 2020–2015, space for the climate[g] Stratégie spatiale française[h] Stratégie national de recherché, France -Europe 2020[i]
Germany	✓			German Aerospace Centre (DLR)	Making Germany's space sector fit for the future - The space strategy of the German Federal Government[j]
Greece			✓	General Secretariat for Research and Technology (GSRT)	
Hungary		✓		Hungarian Space Office (HSO)	Government's mid-term (2007–2013) science, technology and innovation policy (STI) strategy[k]
Ireland			✓	Enterprise Ireland (EI)	Innovation 2020[l]
Italy	✓			Italian Space agency (ASI)	Strategic Vision Document 2016–2025[m]
Luxemburg			✓	Office of Space Affairs in the DG Research, Intellectual Property and New Technologies	Luxembourg: A Pioneer to Space[n]
Netherlands		✓		The Netherlands Space Office (NSO)	Ruimtevaartbeleid 2014–2020[o] Dutch space policy 2017–2019 [p]
Norway		✓		Norwegian Space Centre (NSC)	Between heaven and earth: Norwegian space policy for business and public benefit[q]
Poland	✓			Polish Space agency (POLSA)	National Space Strategy 2017–2030[r]
Portugal			✓	Space Office (FCT)	National Strategy for the space sector[s]
Romania	✓			Romanian Space Agency (ROSA)	National Strategy for Research and Development and Innovation 2014–2020[t]
Spain			✓	Centre for the Development of Industrial Technology (CDTI)	Spanish Strategy for ESA and EU Space Programmes 2007–2011[21]
Sweden	✓			Swedish national Space Board (SNSA)	The Swedish National Space Board's long-term strategy focused on 2016–2020[22] 2018 Swedish National Space Strategy
Switzerland		✓		Swiss Space Office (SSO)	Swiss Space Implementation Plan within Education, Research and Innovation for 2014–2023[23]

(*continued on next page*)

Table 4 (*continued*)

Member state	Agency	Office	Unit	Implementing entity	National space (or innovation) strategy/policy
United Kingdom	✓			United Kingdom Space Agency (UKSA)	National Space Policy[24] National Space Security Policy[u] Space Innovation and Growth Strategy 2014–2030 - Space Growth Action Plan[v] IGS Steering Board and UKSA, UK Space Innovation and Growth Strategy: 2015 Update Report[w]

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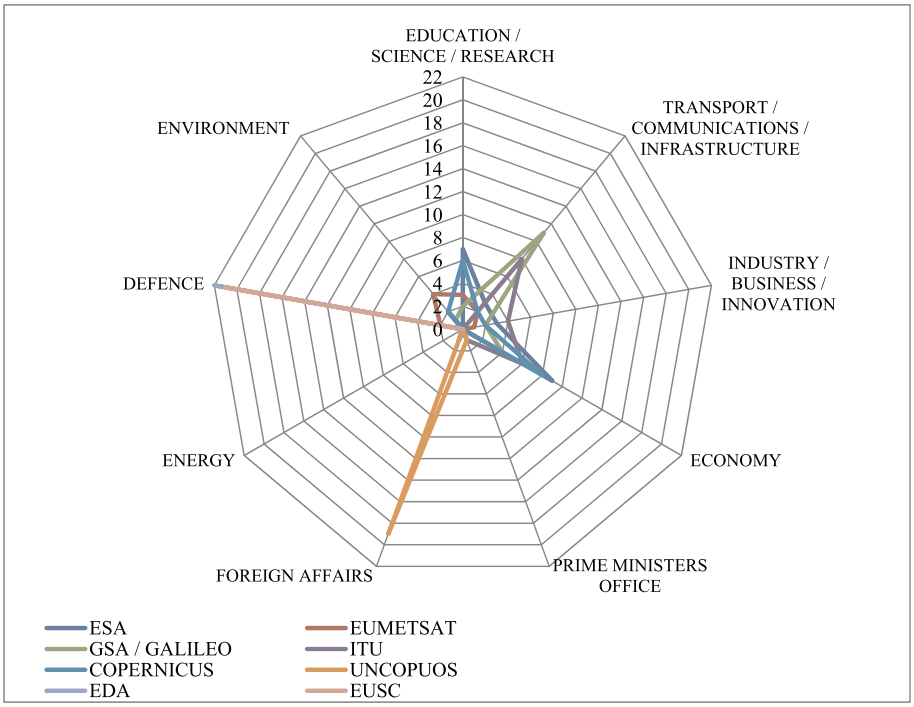

Fig. 2. Ministries responsible for space in ESA twenty-two member states.

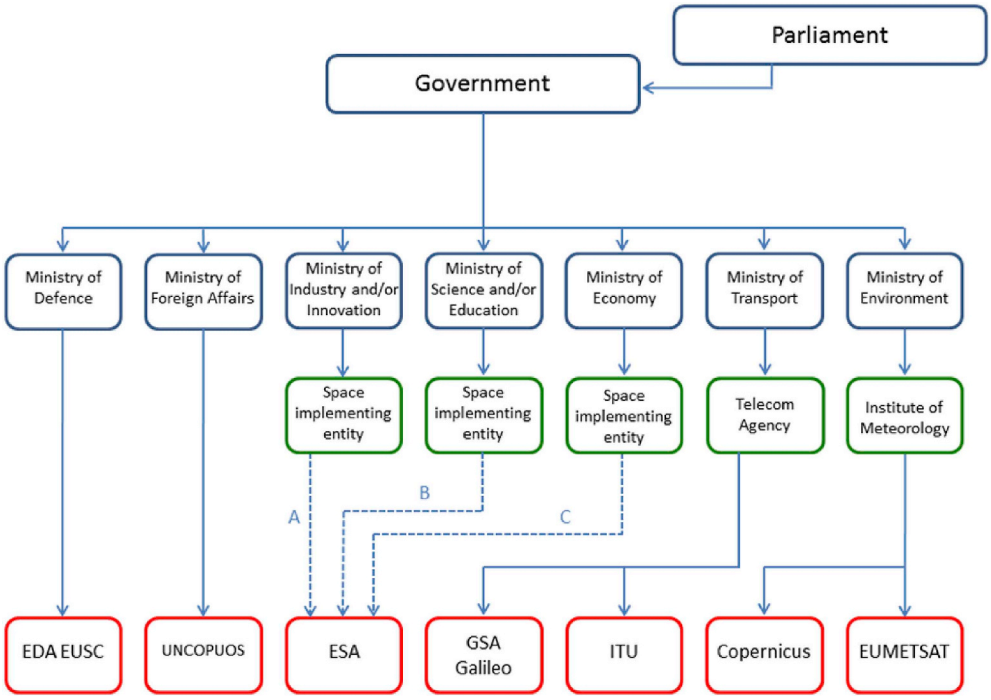

Fig. 3. Archetype of space governance.

long land and/or sea borders, border security is an important area to which space can contribute. In member states with considerable natural resources (including fisheries, mining, energy, etc.), priorities tend to coincide with serving these interests. Moreover, transport and communications are generally seen as an important area for contributions from space assets. It is evident that issues of energy, security, or knowledge and education play important strategic roles. Therefore, the issues considering environment or issues related with exploitation of natural resources may be of importance to strategic policy for many ESA member states.

The analysis of areas of sustainability between 2013 and 2017 shows that knowledge and education, energy, environment and climate

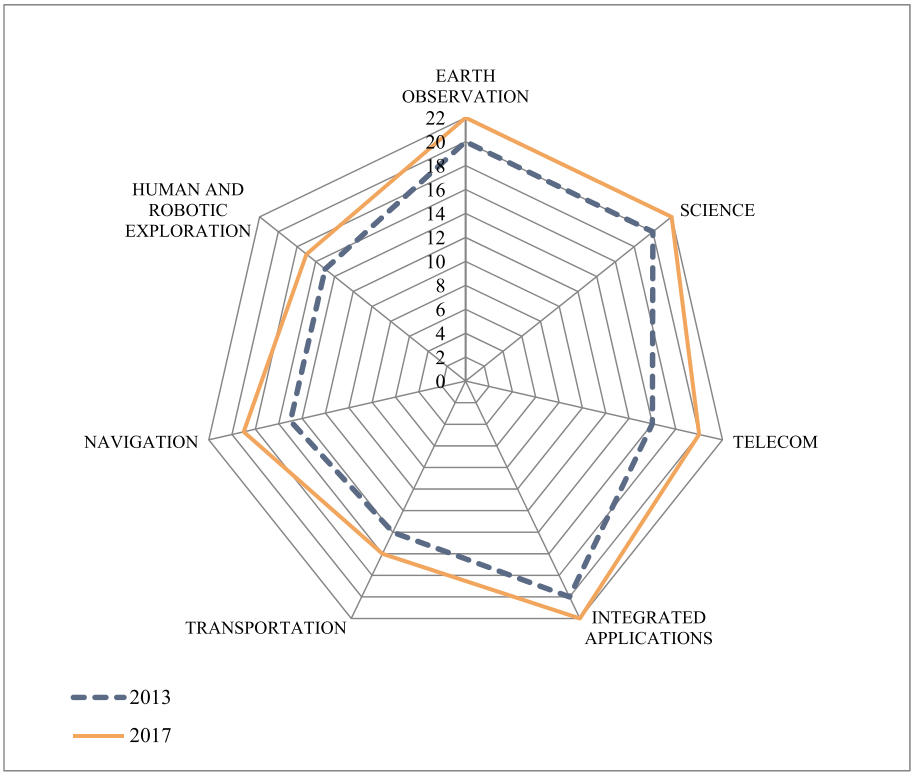

Fig. 4. Public policy priorities for space in technology domains.

change and natural resources are domains that receive increasing emphasis in policy priorities. Small member states show substantially less interest in two areas: energy and environment. Medium-sized or large member states have indicated space as a relevant tool for energy policy and only three out of eleven for climate change and environment. Some of the member states face a more direct impact of the environment and climate change and therefore see space as a tool for support of policies in these areas.

Finally, a number of motivators engaging in space were identified that encourage the involvement of member states in space activities (e.g., [9,10]): technology development and transfer, boosting industrial competitiveness, job creation, social benefits, engagement in international cooperation, and European non-dependence in space (see Fig. 6) [14]. The top motivator for space investments is to increase industrial competitiveness followed closely by the notion of promoting and fostering international cooperation. ESA member states unanimously perceive investments in space as a means to enhance the competitiveness of their respective space sector and space-related industries, or high-tech industry in general. Space is without a doubt an ideal area for international cooperation, as particularly upstream space activities are typically outside of the scope of national territories, a common good, and too expensive for one single state alone to engage in. The motivators for space indicate a significant shift between 2013 and 2017, with a considerable increase of the importance of social benefits and technology development and transfer. The common pattern across the ESA member states is that the industrial competitiveness and international cooperation are the top motivators whereas societal benefits are still to a lesser extend considered.

The role of space in European non-dependence is also an important rationale for public investments in space. This is typically a stronger motivator for the larger space-engaged member states like France. Core technologies here are satellite technology for navigation, satellite communications and earth observation and independent access to satellite data for decision-making. Closely linked to the objective of industrial competitiveness is the potential for technology transfer from space for commercial purposes in terrestrial applications. These motivators are significantly present in all ESA member states.

5. Concluding remarks

This paper aimed to map the existing public policy and space governance and administration dimensions at the level of ESA member states and the factors that drive national space policies and shape national space governance in Europe. We provided a content analysis of space governance structure and public policy priorities for space and compared findings of two (ESA) surveys conducted in 2013 and 2017. In this paper we reflected the complexity of actors, organisations and public policy domains related to the current national strategies for engaging in space. This study's observations contribute to the current systematic effort to facilitate the understanding of exchange and coordination of national space strategies and programmes. Furthermore, it provides practical guidelines for policy-makers for a better orientation in this complex sector. Through the on-going and rapid enlargement of space engagement of states and private sectors, the space administrations need to accommodate to the dynamically changing needs, interests and capabilities of a larger and more heterogeneous European space sector.

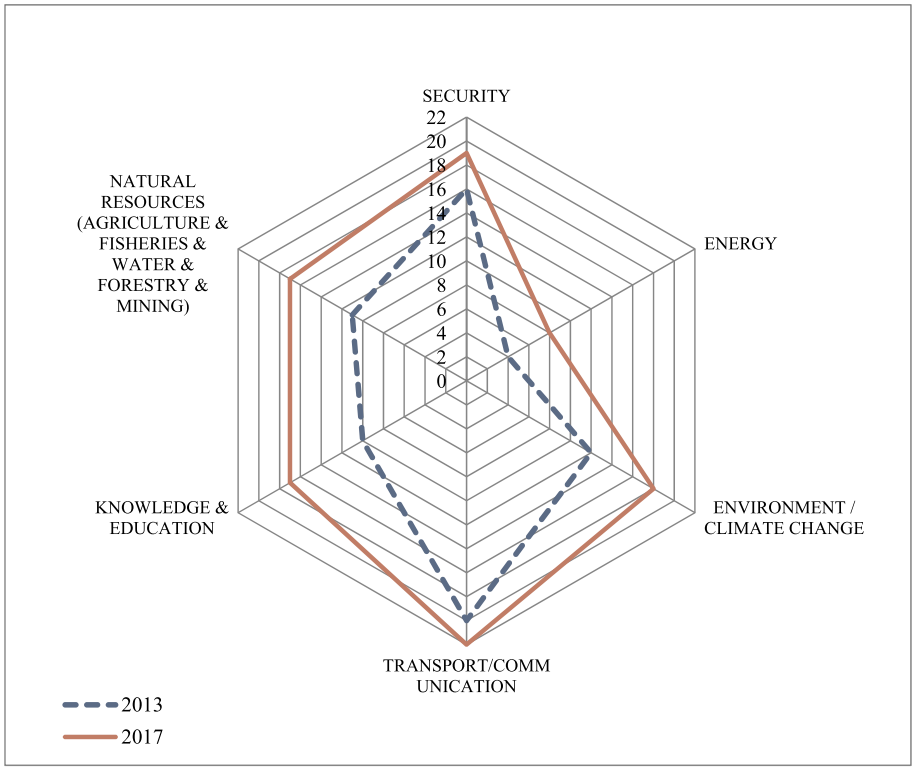

Fig. 5. Public policy priorities for space in areas of sustainability.

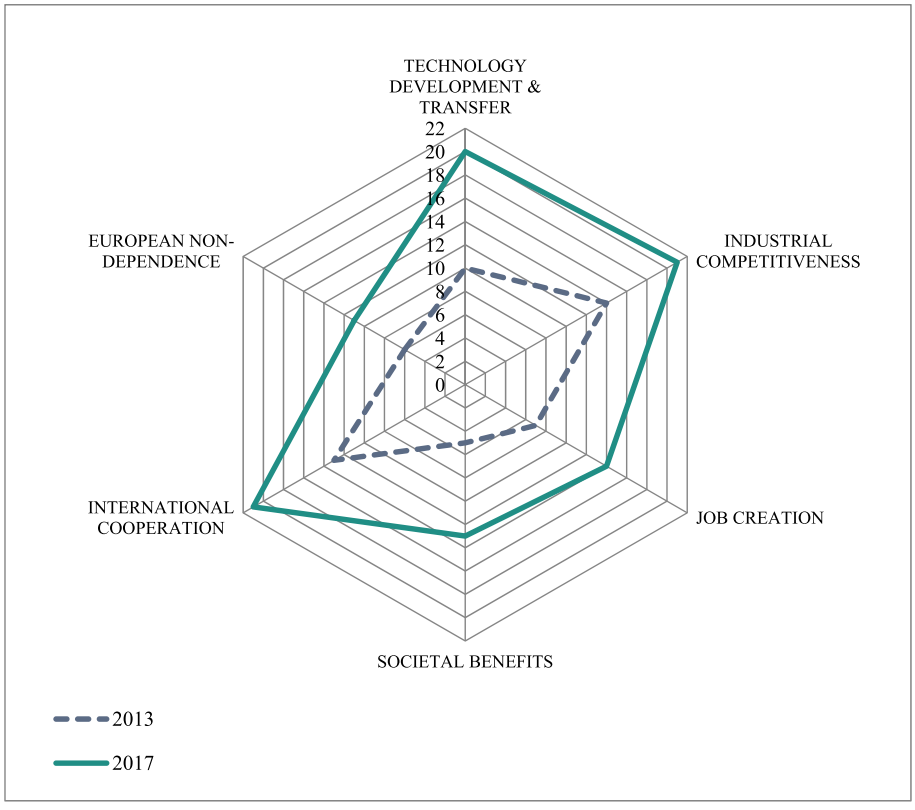

Fig. 6. Public policy motivations for space activities.

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